3GPP TSG-RAN WG2 Meeting #115 electronic ***R2-210xxxx***

Online, Aug 16 – 27, 2021

**Agenda item:** 8.22

**Source:** China Telecom

**Title:** Draft-Summary of [AT115-e][035][NR17] TX switching (China Telecom)

**WID/SID:** NR\_RF\_FR1\_enh

**Document for:** Discussion and Decision

# Introduction

This document is the report of the following email discussion:

* [AT115-e][035][NR17] TX switching (China Telecom)

Scope: Treat papers under 8.22 on TX switching (this section), Determine agreeable points, Reply LS and progress CRs as far as possible

Intended outcome: Report, Approved LS out, CRs

Deadline: CB Friday W1, at least for the report

Rapporteur suggests companies to provide comments **before Thursday W1 UTC 10:00 (August 19**), so that the agreeable part/possible way forwards can be summarized before on-line CB Friday W1 (August 20).

**Contact from companies**

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| --- | --- |
| Company | Email |
| China Telecom | linp@chinatelecom.cn |
| Ericsson | lian.araujo@ericsson.com |
| Qualcomm Incorporated | mkitazoe@qti.qualcomm.com |
| Nokia, Nokia Shanghai Bell | tero.henttonen@nokia.com |
| ZTE | liu.jing30@zte.com.cn |
| MediaTek | chun-fan.tsai@mediatek.com |
| OPPO | qianxi.lu@oppo.com |
| Huawei, HiSilicon | wangrui46@huawei.com |
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# Background

UL Tx switching has been extended to the following scenarios in Rel-17 FR1 RF requirements enhancement WI (with the latest WID in RP-210899).

• 2Tx-2Tx switching between two uplink carriers for SUL and UL CA

• 1Tx-2Tx and 2Tx-2Tx switching between 1 carrier on band A and 2 contiguous aggregated carriers on band B for SUL and UL CA

For the scenario listed in the second bullet, compared to Rel-16 UL Tx switching where only 1 CC on band B, the main point is there are 2 contiguous aggregated carries on band B, and this is supported for 1Tx-2Tx and 2Tx-2Tx switching. The below table illustrates the detailed scenarios.

**Table 1 UL Tx switching scenarios in Rel-16 and Rel-17**

|  |  |  |
| --- | --- | --- |
| Scenario 0 | R16 1T-2T switching | 1 CC on band A, 1 CC on band B |
| Scenario 1 | R17 1T-2T switching | 1 CC on band A, 2 CCs on band B |
| Scenario 2 | R17 2T-2T switching | 1 CC on band A, 1 CC on band B |
| Scenario 3 | R17 2T-2T switching | 1 CC on band A, 2 CCs on band B |

RAN4 has discussed the requirements for the above scenarios, and agreed CR in R4-2103236. In addition, RAN4 sent LS in R4-2103234/ R2-2106951 to RAN2 to deliver the UE capability and RRC configuration related agreements.

RAN1 also discussed this topic in RAN1 #104bis-e meeting, and made the agreements on the supported ports number for each case in each scenarios. During the RAN1 discussion, companies had different views on if a UE is allowed to report different switching time for 1T-2T switching and 2T-2T switching, so the below question is asked to RAN1 in LS R1-2104137/R2-2106907.

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| For UL Tx switching in a band pair of a band combination, whether or not the switching time reported by a UE for 2Tx-2Tx switching can be different from that reported by the UE for 1Tx-2Tx switching. |

In the latest RAN4 reply LS (R4-2107847/R2-2106953), RAN4 answered RAN1’s question about the UL switching time and also made some further clarifications.

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| RAN4 LS (R4-2107847)  RAN1 Question: For UL Tx switching in a band pair of a band combination, whether or not the switching time reported by a UE for 2Tx-2Tx switching can be different from that reported by the UE for 1Tx-2Tx switching.  RAN4 answer:  For UL Tx switching in a band pair of a band combination, the set of candidate switching time for 2Tx-2Tx switching is the same as that for 1Tx-2Tx switching, i.e., the same set of {35us, 140us, 210us}.  The exact reported value of switching time for a band pair of a band combination can be different for 2Tx-2Tx switching and 1Tx-2Tx switching.  Meanwhile, for UE supporting 2Tx-2Tx switching, it means that the UE supports 1Tx-2Tx as well. In the case that UE only reports the capability for 2Tx-2Tx switching, the same switching time can also be applied to 1Tx-2Tx switching. |

In the last RAN2 meeting, the following agreement was achieved on general signalling framework for UE capability reporting.

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| * For Rel-17 UL Tx switching enhancements, RAN2 to use the UE capability reporting signalling framework of R16 1Tx-2Tx UL Tx switching as baseline and assume the R17 UE capability should be reported in the UL Tx switching specific BC list introduced in R16 (i.e. *BandCombinationList-UplinkTxSwitch*) unless issue is found later. |

# Discussion

From RAN2 perspective, the UE capability reporting and RRC configuration should be considered for Rel-17 UL Tx switching enhancement. Based on the company contributions submitted in this meeting, the following issues are raised and need further discussion.

1. How to report RAN4 agreed UE capabilities (related to RF/RRM requirements), e.g. switching time, DL interruptions for UL CA and SUL.
2. How to report UE capabilities related to RAN1 transmission mechanism, e.g. supported switching options for UL CA.
3. RRC signaling configuration, e.g. period location, switching option.

## RAN4 defined UE capability

### DL interruption and UL switching period

**Case 1:** **the scenario 2(Table 1) where 2Tx-2Tx switching between 2 uplinks on band A and band B.**

As discussed, there are two UE capabilities to be reported for Rel-17 UL Tx switching requested by RAN4, i.e. UL switching period and DL interruption.

For **the DL interruption**, RAN4 made clear agreement that there is no different requirement between Rel-17 and Rel-16 UL Tx switching and no RAN4 spec change would be made for Rel-17 UL Tx switching.

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| In RAN4#98e meeting, it was agreed in the WF (R4-2103235) that:  • There is no need to differentiate the DL interruption applicability between Rel-16 1Tx-2Tx switching and Rel-17 Tx switching scenarios, which means that “DL interruption allowed” specified in existing TS 38.101-1 should also be applied to the Rel-17 Tx switching scenarios including:  – 2Tx-2Tx switching between carrier 1 and carrier 2  – 1Tx-2Tx and 2Tx-2Tx switching between band A (carrier 1) and band B (carrier 2+3) |

Based on the above RAN4 WF, [4] and [7] propose that “No need to introduce Rel-17 UE capability of DL interruption for 2Tx-2Tx switching. The Rel-16 UE capability for 1Tx-2Tx switching applies to 2Tx-2Tx switching as well.”

**Q1: For DL interruption for 2Tx-2Tx, do companies agree that no need to introduce Rel-17 UE capability of DL interruption for 2Tx-2Tx? The Rel-16 UE capability for 1Tx-2Tx switching applies to 2Tx-2Tx switching as well?**

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| **Company** | **Agree/ Not agree** | **Comments** |
| China Telecom | Agree | Based on the RAN4 LS and WF, we understand that there is no different requirement for the DL interruption between Rel-17 and Rel-16 UL Tx switching. The Rel-16 UE capability of the DL interruption for 1Tx-2Tx switching can also apply to Rel-17 1Tx-2Tx/2Tx-2Tx switching. No need to introduce Rel-17 UE capability of DL interruption for 2Tx-2Tx switching. |
| Ericsson | Agree | Same view as China Telecom. |
| Qualcomm Incorporated | Need more discussion | RAN2 should establish how the UE can indicate it supports 2Tx-2Tx switching.  We thought it may be based on the number of MIMO layers indicated for carrier 1 and carrier 2. But the current standard says as follows.   * 38.306: "UE shall indicate support for 2-layer UL MIMO capabilities **at least on one** of the indicated two bands for UL Tx switching, and only the band where UE supports 2-layer UL MIMO capability can work as carrier2"   It implies that the UE only supporting 1Tx-2Tx switching could also indicate 2layer-2layer for carrier 1 and carrier 2 in a Tx-switch band combination even today. |
| Nokia, Nokia Shanghai Bell | Maybe (needs more discussion) | No new capability means either that 1) UE has no DL interruption for 2Tx switching or 2) UE DL interruption for 2Tx switching is determined by the 1Tx switching capability.   * + If 1), then we need to make this clear but we thought this may not be always feasible for UEs   + If 2), then we implicitly tie support of 2Tx switching to 1Tx switching and UE cannot have better performance for 2Tx switching DL interruption. This may be fine but we would need to make it clear in specifications to avoid later problems. |
| ZTE | Agree | Same view as China Telecom. |
| MediaTek | Agree | Regarding to Nokia’s question, we understand it is 2). |
| CATT | Agree | Same view as China Telecom |
| OPPO | Agree | Regarding to Nokia’s question, we understand it is 2). |
| Huawei, HiSilicon | Agree | Same view as China Telecom.  1. Regarding Qualcomm’s comments on how to indicate the support of 2Tx-2Tx,   * We agree that the MIMO layers indicated in FeatureSet can be used for that. Since in Rel-16 1Tx-2Tx discussion, we made clear agreement that UE should indicate 1T+2T capability in the uplink Tx switching BC including indicate the support of 2-layer MIMO on the band using 2Tx. The description in 38306 could be updated after we conclude how to capture 2Tx-2Tx, since the same parameter may/may not apply to 2Tx-2Tx. * In addition to MIMO layer, the present of Rel-17 2T-2T switching time can also serve this purpose. As option1 illustrated in Q2, if Rel-17 network find a Rel-17 switching time in the Rel-17 band pair extension (include a different value, or a absent value), it can further look into the FeatureSet for detailed capability, otherwise the NW know the UE does not support 2T-2T switching, then no need to peel all FS entries.   2. Regarding Nokia’s comments, we also understand it is 2). |
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For **the UL switching period**, based on the latest RAN4 LS [3], it was clarified that the exact reported value of switching time for a band pair of a band combination can be different for 2Tx-2Tx switching and 1Tx-2Tx switching. Therefore, UE shall at least be able to indicate different switching time for 2Tx-2Tx and 1Tx-2Tx for Rel-17 UL Tx switching.

In [4], [6], [7] and [8], different ways to indicate different switching time for 2Tx-2Tx and 1Tx-2Tx for a band pair of a band combination are proposed. Two options are summarized as follows.

**Option 1:** **To introduce Rel-17 per-band pair UE capability for a given BC for 2Tx-2Tx switching to indicate a different switching time. (Proposed in [4], [7] and [8])**

**Option 2: To report different band combinations indicating different switching times, without introducing Rel-17 per-band pair UE capability for a given BC 2Tx-2Tx switching. (Proposed in [6])**

In Option 1, UE can report the support of 1Tx-2Tx switching and 2Tx-2Tx switching in the same BC. Different switching time for 2Tx-2Tx and 1Tx-2Tx for a band pair can be explicit reported. If not explicit reported, the same switching time can be applied to both 1Tx-2Tx switching and 2Tx-2Tx switching. The possible TP for TS 38.331 is as follows.

Option 1 possible TP proposed in [7] is showed below.

BandCombination-UplinkTxSwitch-r16 ::= SEQUENCE {

bandCombination-r16 BandCombination,

bandCombination-v1540 BandCombination-v1540 OPTIONAL,

bandCombination-v1560 BandCombination-v1560 OPTIONAL,

bandCombination-v1570 BandCombination-v1570 OPTIONAL,

bandCombination-v1580 BandCombination-v1580 OPTIONAL,

bandCombination-v1590 BandCombination-v1590 OPTIONAL,

bandCombination-v1610 BandCombination-v1610 OPTIONAL,

supportedBandPairListNR-r16 SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-r16,

uplinkTxSwitching-OptionSupport-r16 ENUMERATED {switchedUL, dualUL, both} OPTIONAL,

uplinkTxSwitching-PowerBoosting-r16 ENUMERATED {supported} OPTIONAL,

...

}

BandCombination-UplinkTxSwitch-v1630 ::= SEQUENCE {

bandCombination-v1630 BandCombination-v1630 OPTIONAL

}

BandCombination-UplinkTxSwitch-v1640 ::= SEQUENCE {

bandCombination-v1640 BandCombination-v1640 OPTIONAL

}

BandCombination-UplinkTxSwitch-v17xx ::= SEQUENCE {

supportedBandPairListNR-v17xx SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-v17xx OPTIONAL

}

ULTxSwitchingBandPair-r16 ::= SEQUENCE {

bandIndexUL1-r16 INTEGER(1..maxSimultaneousBands),

bandIndexUL2-r16 INTEGER(1..maxSimultaneousBands),

uplinkTxSwitchingPeriod-r16 ENUMERATED {n35us, n140us, n210us},

uplinkTxSwitching-DL-Interruption-r16 BIT STRING (SIZE(1..maxSimultaneousBands)) OPTIONAL

}

ULTxSwitchingBandPair-v17xx ::= SEQUENCE {

uplinkTxSwitchingPeriod2T2T-r17 ENUMERATED {n35us, n140us, n210us} OPTIONAL,

...

}

Option 1 possible TP proposed in [8] is showed below.

BandCombination-UplinkTxSwitch-r16 ::= SEQUENCE {

bandCombination-r16 BandCombination,

bandCombination-v1540 BandCombination-v1540 OPTIONAL,

bandCombination-v1560 BandCombination-v1560 OPTIONAL,

bandCombination-v1570 BandCombination-v1570 OPTIONAL,

bandCombination-v1580 BandCombination-v1580 OPTIONAL,

bandCombination-v1590 BandCombination-v1590 OPTIONAL,

bandCombination-v1610 BandCombination-v1610 OPTIONAL,

supportedBandPairListNR-r16 SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-r16,

uplinkTxSwitching-OptionSupport-r16 ENUMERATED {switchedUL, dualUL, both} OPTIONAL,

uplinkTxSwitching-PowerBoosting-r16 ENUMERATED {supported} OPTIONAL,

...

}

BandCombination-UplinkTxSwitch-v1630 ::= SEQUENCE {

bandCombination-v1630 BandCombination-v1630 OPTIONAL

}

BandCombination-UplinkTxSwitch-v16xy ::= SEQUENCE {

bandCombination-v16xy BandCombination-v16xy OPTIONAL

}

BandCombination-UplinkTxSwitch-v17xx ::= SEQUENCE {

supportedBandPairListNR1Tx2TxThree-r17 SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-r17 OPTIONAL,

supportedBandPairListNR2Tx2TxTwo-r17 SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-r17 OPTIONAL,

supportedBandPairListNR2Tx2TxThree-r17 SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-r17 OPTIONAL

}

ULTxSwitchingBandPair-r16 ::= SEQUENCE {

bandIndexUL1-r16 INTEGER(1..maxSimultaneousBands),

bandIndexUL2-r16 INTEGER(1..maxSimultaneousBands),

uplinkTxSwitchingPeriod-r16 ENUMERATED {n35us, n140us, n210us},

uplinkTxSwitching-DL-Interruption-r16 BIT STRING (SIZE(1..maxSimultaneousBands)) OPTIONAL

}

ULTxSwitchingBandPair-r17 ::= SEQUENCE {

bandAIndexUL-r17 INTEGER(1..maxSimultaneousBands),

bandBIndexUL-r17 INTEGER(1..maxSimultaneousBands),

uplinkTxSwitchingPeriod-r17 ENUMERATED {n35us, n140us, n210us},-- TBD by RAN4

uplinkTxSwitching-DL-Interruption-r17 BIT STRING (SIZE(1..maxSimultaneousBands)) OPTIONAL -- TBD by RAN4

}

In Option 2, UE reports two different BCs (BC1 and BC2) in *supportedBandPairListNR-r16* to indicating different switching time. For example,

BC1 (Band A + Band B): the UE includes support for 1Tx-2Tx and the UE includes support for 2Tx-2Tx. It sets the switching period value to 140us (i.e. this switching period is applicable to both 1Tx-2Tx and 2Tx-2Tx).

BC2 (Band A + Band B): the UE includes support for 1Tx-2Tx and the UE does not include support for 2Tx-2Tx. It sets the switching period value to 35us (i.e. this switching period is applicable only to 1Tx-2Tx).

In that way, the UE can indicate in BC2 better capabilities concerning the switching period, compared to what it signaled in BC1.

Option 2 may bring some additional overhead since the UE would report two different band combinations for the sake of indicating different switching times. Other per BC UE capabilities may be duplicated reported.

Option 2 possible TP proposed in [6] is showed below.

BandCombination-UplinkTxSwitch-r16 ::= SEQUENCE {

bandCombination-r16 BandCombination,

bandCombination-v1540 BandCombination-v1540 OPTIONAL,

bandCombination-v1560 BandCombination-v1560 OPTIONAL,

bandCombination-v1570 BandCombination-v1570 OPTIONAL,

bandCombination-v1580 BandCombination-v1580 OPTIONAL,

bandCombination-v1590 BandCombination-v1590 OPTIONAL,

bandCombination-v1610 BandCombination-v1610 OPTIONAL,

supportedBandPairListNR-r16 SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-r16,

uplinkTxSwitching-OptionSupport-r16 ENUMERATED {switchedUL, dualUL, both} OPTIONAL,

uplinkTxSwitching-PowerBoosting-r16 ENUMERATED {supported} OPTIONAL,

...

}

BandCombination-UplinkTxSwitch-v1630 ::= SEQUENCE {

bandCombination-v1630 BandCombination-v1630 OPTIONAL

}

BandCombination-UplinkTxSwitch-v1640 ::= SEQUENCE {

bandCombination-v1640 BandCombination-v1640 OPTIONAL

}

BandCombination-UplinkTxSwitch-v17xx ::= SEQUENCE {

uplinkTxSwitching-r17 ENUMERATED {twoTx-twoTx} OPTIONAL

}

**Q2: For indicating different UL switching time (i.e. UL switching period) for 2Tx-2Tx and 1Tx-2Tx for a band pair of a band combination, which option do companies prefer?**

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| **Company** | **Option 1/Option 2** | **Comments** |
| China Telecom | Option 1 | Option 1 tends to reuse the Rel-16 framework as much as possible, and UE can report the support of 1Tx-2Tx switching and 2Tx-2Tx switching in the same BC, which can avoid reporting other per BC capabilities duplicated. The signalling overhead is relatively small.  For Option 2, we have concerns on the additional overhead caused by reporting two different band combinations for the sake of indicating different switching times. Other per BC UE capabilities may be duplicated reported. As mentioned in R2-2107979, “the scenarios where switching times between 2Tx-2Tx and 1Tx-2Tx differ should not be the usual case but rather a more particular one, hence the overhead should not be that big”. We tend to agree that the signalling overhead somehow depends on whether different UL switching time for 1Tx-2Tx and 2Tx-2Tx is a common case or not. But we are wondering whether it is really a more particular or unusual case to have different UL switching time for 1Tx-2Tx and 2Tx-2Tx? |
| Ericsson | Option 2 | As discussed above, we think the signalling of different UL switching time for 1Tx-2Tx and 2Tx-2Tx should not be a common case and thus the signalling could be reused. Note we also agreed previously to use the UE capability reporting signalling framework of R16 1Tx-2Tx UL Tx switching as baseline, so we should strive to reuse as much as possible. |
| Qualcomm Incorporated | Option 2? | Again, RAN2 should establish how the UE can indicate it supports 2Tx-2Tx switching (see our input to Q1).  But assuming 1Tx-2Tx and 2Tx-2Tx cases can be distinguished based on the number of MIMO layers supported in carrier 1 and carrier 2, option 2 is sufficient.  This also satisfies what RAN4 indicated.   * + The set of candidate switching time for 2Tx-2Tx switching is the same as that for 1Tx-2Tx switching, i.e., the same set of {35us, 140us, 210us}.   + The exact reported value of switching time for a band pair of a band combination can be different for 2Tx-2Tx switching and 1Tx-2Tx switching.   + Meanwhile, for UE supporting 2Tx-2Tx switching, it means that the UE supports 1Tx-2Tx as well. The switching time capability for 2Tx-2Tx is applied to 1Tx-2Tx switching in this case. |
| Nokia, Nokia Shanghai Bell | Option 2? | Agree with Qualcomm: This depends on how UE indicates 2TX switching support. We should ensure that it's clear to network in which band combinations UE supports (only) 1Tx switching and in which it support 2Tx switching. As QC said, if the number of MIMO layers is the distinguishing factor, then option 2 seems fine.  Generally, we assume that whenever UE indicates support for 2Tx switching, it also supports 1Tx switching with the same parameters. If this is the common understanding, it would be good to clarify. |
| ZTE | Option 1 | We have some questions to Option 2:   1. In the example given by Rapporteur, for 1Tx-2Tx, should network respect the capability reported in BC1 or BC2 (e.g. 140us or 35us)? 2. For 1Tx-2Tx, can UE report different feature set capability in BC1 and BC2? If UE can, which one should be followed by network?   We original thought in Option 2, the BC with *uplinkTxSwitching-r17* set to *twoTx-twoTx* is only applicable to 2Tx-2Tx, but if it is applicable to both 1Tx-2Tx and 2Tx-2Tx, then above questions need to be clarified. |
| MediaTek | Option 1 |  |
| CATT | Option 1 | In option 2, UE shall repeatedly report the other per-BC capabilities except the UL switching time. |
| OPPO | Option 1 | We tend to agree it is helpful to clarify the issue raised by QC that how UE indicates 2TX switching support, or may more specifically, if the UE report 2-layer MIMO for both bands, and if the concerned band pair is reported as supported Tx-switching, whether it support 2T-2T switching only or 1T-2T switching as well – our understanding is yes, and therefore logically there should be no BC supporting 2T-2T only.  Then for the need of solution-2, as commented above, it is mainly about whether it is a corner case so need to introduce new signalling as in solution-1, or if it is not corner, solution-1 is straightforward. From our perspective, solution-1 is safer since one cannot judge whether it is a corner case or not, by risking on signalling overhead. |
| Huawei, HiSilicon | Option 1 | Similar views as OPPO, it is not sure for us the 2Tx-2Tx sharing the same switching time with 1Tx-2Tx switching is the common case. This is quite related to UE implementation, and different switching time already confirmed by RAN1 and RAN4, so we’d better indicating it via explicit signalling.  Option2 has more signalling overhead than option1. In case the only different capability for a UE supporting 1T-2T and 2T-2T is the switching time, then the UE needs to repeat all the same capability (other per-BC cap and the cap in FS of 1T-2T) in both BC1 and BC2. And in option1 example 1, the Rel-17 switching time is in the extension of the Rel-16 band pair, not much signalling will be introduced. |
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For **whether Rel-16 filter *uplinkTxSwitchRequest-r16* can be reused or not to request Rel-17 UL Tx switching UE capability**.

In [4] and [7], another issue of whether Rel-16 filter uplinkTxSwitchRequest-r16 can be reused or not to request Rel-17 UL Tx switching UE capability is raised.

As clarified in RAN4 LS that “if a UE supports 2Tx-2Tx switching it also supports 1Tx-2Tx switching”, it makes sense considering the Rel-17 2Tx-2Tx switching is the enhancement of the Rel-16 1Tx-2Tx switching. Then from UE capability reporting point of view, it should also consider inter-operability between UE supporting Rel-17/Rel-16 UL Tx switching and NW supporting Rel-17/Rel-16 UL Tx switching. In Rel-16, a UE will only report the UE capability of UL Tx switching in *supportedBandCombinationList-UplinkTxSwitch* based on network request via filter *uplinkTxSwitchRequest-r16*. In Rel-17, from network side the existing filter should be used to request the UL Tx switching capability including both Rel-16 and Rel-17 UL switching capabilities. From UE side, the UE only supporting Rel-16 switching handles the filter as in legacy, while for the UE supporting Rel-17 switching (means also supporting Rel-16 switching) reports the Rel-17 UE capability, and also reports the Rel-16 UE capability as the filter may be from Rel-16 network which cannot understand the Rel-17 UE capability.

Based on the above analysis, [4] and [7] propose that “Rel-16 filter *uplinkTxSwitchRequest-r16* is reused to request Rel-17 UL Tx switching UE capability. A UE supporting 2Tx-2Tx switching should report the UE capabilities of 2Tx-2Tx switching and 1Tx-2Tx switching”.

**Q3: Do companies agree that “the Rel-16 filter *uplinkTxSwitchRequest-r16* can be reused to request Rel-17 UL Tx switching UE capability”?**

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| **Company** | **Agree/ Not agree** | **Comments** |
| China Telecom | Agree | Based on the RAN4 clarification that “if a UE supports 2Tx-2Tx switching it also supports 1Tx-2Tx switching”, we understand that Rel-17 2Tx-2Tx switching is the enhancement of the Rel-16 1Tx-2Tx switching. We think reusing Rel-16 filter to request Rel-17 UL Tx switching UE capability is feasible and no inter-operability issue is seen. |
| Ericsson | Agree | Add different filter handling would just make the feature more complex. While if a network is interested on both Rel-16 and Rel-17 capabilities, it would have to anyway include both fields for Rel-16 and Rel-17 in the filter request. |
| Qualcomm Incorporated | Agree |  |
| Nokia, Nokia Shanghai Bell | Agree | There's no need for additional filters here as long as the capabilities are backward-compatible (which they should always be). |
| ZTE | Agree |  |
| MediaTek | Agree |  |
| CATT | Agree | RAN4 already clarified that the UE supports 2Tx-2Tx switching also supports 1Tx-2Tx switching, thus reusing Rel-16 filter to request Rel-17 UL Tx switching UE capability is feasible and easier compared with introducing additional Rel-17 filter. |
| OPPO | Agree |  |
| Huawei, HiSilicon | Agree |  |
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**Case 2:** **the scenarios 1&3 where 1CC@band A and 2CCs@band B**

In [4] and [7], it is mentioned that RAN4’s assumption is that UE will use the same transceiver to cover the 2 contiguous CCs on band B, so there is no extra requirement defined for the scenarios with 2CCs@band B compared with the scenarios with 1CC@band B.

In order to make progress, [4] gives two way forwards for R17 1Tx-2Tx/2Tx-2Tx switching between 1 carrier on band A and 2 contiguous aggregated carriers on band B for SUL and UL CA.

**Way-forward 1a: the UE should report corresponding CA bandwidth class and UL MIMO layers in the UL featureSetPerCCs for 2 continuous CCs on band B in the legacy way. No new UE capability is needed specific to the case with 2CCs on band B.**

**Way-forward 1b: the independent capability of UL switching period is introduced from the one reported for the scenarios with 1CC on band B.**

For way-forward 1a, there is no need to introduce new capability to differentiate 2CCs@band B or 1CC@band B, apart from the existing CA bandwidth class and UL MIMO layers in the UL featureSetPerCC.

For way-forward 1b, a UE supporting Rel-17 UL Tx switching can report the same value or different values of switching period for the switching scenarios between 1Tx and 2Tx, with 1CC or 2CCs on band B. The benefit is leaving full flexibility to UE implementation, at the cost of a bit more signalling overhead.

Possible TP for way-forward 1b is showed below.

BandCombination-UplinkTxSwitch-r16 ::= SEQUENCE {

bandCombination-r16 BandCombination,

bandCombination-v1540 BandCombination-v1540 OPTIONAL,

bandCombination-v1560 BandCombination-v1560 OPTIONAL,

bandCombination-v1570 BandCombination-v1570 OPTIONAL,

bandCombination-v1580 BandCombination-v1580 OPTIONAL,

bandCombination-v1590 BandCombination-v1590 OPTIONAL,

bandCombination-v1610 BandCombination-v1610 OPTIONAL,

supportedBandPairListNR-r16 SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-r16,

uplinkTxSwitching-OptionSupport-r16 ENUMERATED {switchedUL, dualUL, both} OPTIONAL,

uplinkTxSwitching-PowerBoosting-r16 ENUMERATED {supported} OPTIONAL,

...

}

BandCombination-UplinkTxSwitch-v1630 ::= SEQUENCE {

bandCombination-v1630 BandCombination-v1630 OPTIONAL

}

BandCombination-UplinkTxSwitch-v1640 ::= SEQUENCE {

bandCombination-v1640 BandCombination-v1640 OPTIONAL

}

BandCombination-UplinkTxSwitch-v17xx ::= SEQUENCE {

supportedBandPairListNR-v17xx SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-v17xx OPTIONAL

}

ULTxSwitchingBandPair-r16 ::= SEQUENCE {

bandIndexUL1-r16 INTEGER(1..maxSimultaneousBands),

bandIndexUL2-r16 INTEGER(1..maxSimultaneousBands),

uplinkTxSwitchingPeriod-r16 ENUMERATED {n35us, n140us, n210us},

uplinkTxSwitching-DL-Interruption-r16 BIT STRING (SIZE(1..maxSimultaneousBands)) OPTIONAL

}

ULTxSwitchingBandPair-v17xx ::= SEQUENCE {

uplinkTxSwitchingPeriod1T-2T2CC-r17 ENUMERATED {n35us, n140us, n210us} OPTIONAL,

uplinkTxSwitchingPeriod2T-2T1CC-r17 ENUMERATED {n35us, n140us, n210us} OPTIONAL,

uplinkTxSwitchingPeriod2T-2T2CC-r17 ENUMERATED {n35us, n140us, n210us} OPTIONAL,

…

}

**Q4: For R17 1Tx-2Tx/2Tx-2Tx switching between 1 carrier on band A and 2 contiguous aggregated carriers on band B for SUL and UL CA, which way-forward do companies prefer?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Way-forward 1a/ Way-forward 1b** | **Comments** |
| China Telecom | Way-forward 1a | We prefer Way-forward 1a, which can minimize signalling overhead for Rel-17 UL Tx switching UE capabilities reporting.  Way-forward 1b has a bit more signaling overhead, but we are also open to Way-forward 1b, if companies want to leave full flexibility to UE implementation. |
| Ericsson | Way-forward 1a | We should strive to reuse the signalling as much as possible. So given that the current signalling can already accommodate this case, we should not introduce new capabilities for this sake. |
| Qualcomm Incorporated | 1a? | RAN2 should establish how the UE can indicate it supports 2Tx-2Tx switching.  We thought it may be based on the number of MIMO layers indicated for carrier 1 and carrier 2. But the current standard says as follows.   * 38.306: "UE shall indicate support for 2-layer UL MIMO capabilities **at least on one** of the indicated two bands for UL Tx switching, and only the band where UE supports 2-layer UL MIMO capability can work as carrier2"   It implies that the UE only supporting 1Tx-2Tx switching could also indicate 2layer-2layer for carrier 1 and carrier 2 in a Tx-switch band combination even today. |
| Nokia, Nokia Shanghai Bell | 1a | If 1a works and no issues are found, it seems preferable due to signalling reuse (as commented by Ericsson). The question from QC is a good one and should be clarified before going forward. |
| ZTE | Up to RAN4? | If we understand the question correctly, it means whether UE must report the same switch period for 2CCs@BandB and 1CC@BandB?  RAN4 replied in R2-2106907 that different switch periods may be needed for 1Tx-2Tx and 2Tx-2Tx, but they did not mention the case between 2CCs@BandB and 1CC@BandB. But if majority companies think the same switch period can be applied, then we are ok. |
| MediaTek |  | This part is not so clear from RAN4 LS and we assume that we could wait for R4 to provide further guideline. |
| CATT | Way-forward 1a | No need to introduce new capabilities at the cost of signalling overhead, anyway the current signalling can be reused. |
| OPPO | 1a or up to RAN4 | And we are also fine to wait for R4, or check with R4 directly via LS on this. |
| Huawei, HiSilicon | Way-forward 1a | As discussed in Q5, seems it is the common understanding that the fallback from 2CC to 1CC on band B is supported as legacy. Then it implies that the capability of 2CC case can apply to 1CC case.  We can take WF 1a as RAN2 understanding. |
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For **the fallback capability from 2 CCs to 1 CC**

In [4] and [7], another issue of whether the fallback capability from 2CCs to 1CC should be supported in the legacy way is raised.

For legacy CA the fallback capability is supported when remove one CC to reduce signalling overhead, while for UL Tx switching, we do not identify any issue for supporting the fallback capability. And as in legacy, the UE is allowed to report different fallback anyway, e.g. in different featureset combination or different band combination.

Based on the above analysis, [4] and [7] propose that “On band B, the fallback capability from 2 CCs to 1 CC can be supported in the legacy way”.

**Q5: Do companies agree that “On band B, the fallback capability from 2 CCs to 1 CC can be supported in the legacy way”?**

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| --- | --- | --- |
| **Company** | **Agree/ Not agree** | **Comments** |
| China Telecom | Agree | We do not identify any issue for supporting the fallback capability in the legacy way. We support the proposal that “On band B, the fallback capability from 2 CCs to 1 CC can be supported in the legacy way”. |
| Ericsson | Agree | We think the support of fallback capability is a basic principle and should be followed unless there is an extreme justification to deviate from it. Hence we se no need to design this capability differently. |
| Qualcomm Incorporated | Agree |  |
| Nokia, Nokia Shanghai Bell | Agree | This seems like a reasonable assumption and simplifies the design. |
| ZTE | Agree | Seems ok unless RAN1 identify problems. |
| MediaTek | Agree |  |
| CATT | Agree |  |
| OPPO | Agree |  |
| Huawei, HiSilicon | Agree |  |
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### Other related issues

**Issue 1: The band type**

In [8], it is proposed that “**For R17 UL Tx switching, the UE reports the *bandIndexUL* according to the band type, and the serving cell indicates the band type of its carrier**.”

The proposed TP in [8] is showed below.

BandCombination-UplinkTxSwitch-r16 ::= SEQUENCE {

bandCombination-r16 BandCombination,

bandCombination-v1540 BandCombination-v1540 OPTIONAL,

bandCombination-v1560 BandCombination-v1560 OPTIONAL,

bandCombination-v1570 BandCombination-v1570 OPTIONAL,

bandCombination-v1580 BandCombination-v1580 OPTIONAL,

bandCombination-v1590 BandCombination-v1590 OPTIONAL,

bandCombination-v1610 BandCombination-v1610 OPTIONAL,

supportedBandPairListNR-r16 SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-r16,

uplinkTxSwitching-OptionSupport-r16 ENUMERATED {switchedUL, dualUL, both} OPTIONAL,

uplinkTxSwitching-PowerBoosting-r16 ENUMERATED {supported} OPTIONAL,

...

}

BandCombination-UplinkTxSwitch-v1630 ::= SEQUENCE {

bandCombination-v1630 BandCombination-v1630 OPTIONAL

}

BandCombination-UplinkTxSwitch-v16xy ::= SEQUENCE {

bandCombination-v16xy BandCombination-v16xy OPTIONAL

}

BandCombination-UplinkTxSwitch-v17xx ::= SEQUENCE {

supportedBandPairListNR1Tx2TxThree-r17 SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-r17 OPTIONAL,

supportedBandPairListNR2Tx2TxTwo-r17 SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-r17 OPTIONAL,

supportedBandPairListNR2Tx2TxThree-r17 SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-r17 OPTIONAL

}

ULTxSwitchingBandPair-r16 ::= SEQUENCE {

bandIndexUL1-r16 INTEGER(1..maxSimultaneousBands),

bandIndexUL2-r16 INTEGER(1..maxSimultaneousBands),

uplinkTxSwitchingPeriod-r16 ENUMERATED {n35us, n140us, n210us},

uplinkTxSwitching-DL-Interruption-r16 BIT STRING (SIZE(1..maxSimultaneousBands)) OPTIONAL

}

ULTxSwitchingBandPair-r17 ::= SEQUENCE {

bandAIndexUL-r17 INTEGER(1..maxSimultaneousBands),

bandBIndexUL-r17 INTEGER(1..maxSimultaneousBands),

uplinkTxSwitchingPeriod-r17 ENUMERATED {n35us, n140us, n210us},-- TBD by RAN4

uplinkTxSwitching-DL-Interruption-r17 BIT STRING (SIZE(1..maxSimultaneousBands)) OPTIONAL -- TBD by RAN4

}

It also mentioned that “For uplink Tx switching between 1 carrier on Band A and 2 contiguous carriers on Band B, whether Tx switching between 2Tx on Band A and 1Tx on Band A+1Tx on Band B for UL CA option 1 and SUL is included in WID could be clarified by RAN plenary or RAN4.” It was discussed in RP-211587 in the RAN#92e with no consensus reached. Based on the latest WID, these scenarios are not included in scope of Rel-17 UL Tx switching enhancements.

Moreover, according to RAN4’s clarification in the reply LS “for UE supporting 2Tx-2Tx switching, it means that the UE supports 1Tx-2Tx as well”, we understand there seems no need to explicitly indicate the band type.

If companies have different understandings or clarifications on this issue, further comments or questions are welcome.

**Q6: For R17 UL Tx switching, do companies think that “the UE needs to report the *bandIndexUL* according to the band type”?**

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| --- | --- | --- |
| **Company** | **Yes/ No** | **Comments** |
| China Telecom | May be No | We do not fully understand the intention of report the *bandIndexUL* according to the band type. But we are open to have further discussion or clarifications. |
| Ericsson | No | We do not see a need for adding this behaviour, while it also seems to imply in extra complexity. |
| Qualcomm Incorporated |  | Some clarifications from the proponent are necessary. |
| Nokia, Nokia Shanghai Bell | No? | Perhaps this also ties to the overall question asked by QC: How exactly does UE indicate the 2TX switching? Once we answer that, it will be easier to see if this proposal makes sense. |
| ZTE |  | Clarification is needed, does it mean only the band indicated in “bandBIndexUL-r17” can be configured as carrier 2/3 in UL Tx switching? |
| MediaTek |  | The wording in this proposal is not so clear to us. Perhaps this detail ASN.1 could be discussed later |
| CATT | No | Agree with China Telecom |
| OPPO | No |  |
| Huawei, HiSilicon | No | Assuming the support of 2Tx is indicated in FS and the support of 2CCs is indicated in bandwidth class and FSperCC, we don’t see other indication is needed. |
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**Issue 2: Power boosting in UL Tx Switching**

In [5], whether *uplinkTxSwitching-PowerBoosting-r16* is needed or not for Rel-17 UL Tx switching is discussed. It proposes that “*uplinkTxSwitching-PowerBoosting-r16* is no longer needed for Rel-17 UL Tx Switching”.

For the power boosting capability, it has been brought up in RAN4 and RAN1, but no agreement was achieved.

In addition, RAN4 has agreed to introduce PC2 in TDD intra-band contiguous and non-contiguous UL CA, which means the Rel-16 feature of power boosting in UL Tx switching is no longer needed.

**Q7: Do companies agree that “*uplinkTxSwitching-PowerBoosting-r16* is no longer needed for Rel-17 UL Tx Switching”?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/ No** | **Comments** |
| Chine Telecom | Yes | We share the same view that *uplinkTxSwitching-PowerBoosting-r16* is no longer needed for Rel-17 UL Tx Switching.  For the “power boosting” capability, it has already been discussed in RAN4. And in the RAN4 approved feature CR (R4-2103236), this capability is not included. So in our opinion, the capability of power boosting is only related to Rel-16. |
| Ericsson | Wait for RAN4 | This is being discussed in RAN4 also, so we should wait for them before rushing any conclusion in RAN2. |
| Qualcomm Incorporated | No RAN2 impact | The proposal does not seem to affect RAN2 specification anyway, because the current text already relies on RAN4 specification regarding the applicability. |
| Nokia, Nokia Shanghai Bell | No (wait for RAN4) | Agree with both Ericsson and QC: We cannot remove (i.e. dummify) the capability in Rel-17 anyway, so it's unclear what this proposal means: Even if we have PC2, legacy behaviour must still be allowed. RAN2 should wait for RAN4 before doing anything. |
| ZTE | Wait for RAN4 | RAN2 never discuss the necessity of this capability. |
| MediaTek | Wait for RAN4 |  |
| CATT | Yes | Agree with China Telecom |
| OPPO | Wait for RAN4 |  |
| Huawei, HiSilicon | Yes | Our understanding is that this issue has been brought up in RAN4 in previous meetings, and RAN4 did not support power boosting for 2T-2T switching.  But we also agree with Qualcomm, there could be no/minor RAN2 spec impact, if there is no RAN4 requirement of power boosting for 2Tx-2Tx switching case, it means no support of it. |
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## RAN1 defined UE capability

Regarding the switching option in case of inter-band CA, in RAN1 #105e meeting, it was agreed that the mechanism of uplink switching specified for SUL and UL CA option 1 (i.e. switchedUL) in Rel-16 1Tx-2Tx will be reused for Rel-17 2Tx-2Tx switching between two UL carriers, i.e. scenario 2 from Table1. Meanwhile for UL CA option2 (i.e. dualUL), as the switching among multiple transmission states is more complex, it has not been decided whether the Rel-16 mechanism and corresponding description can be reused (with something add-on).

Although the detailed RAN1 discussion on the switching option for inter-band CA is not totally completed, we can try to discuss how to handle the UE capability signalling of supported switching options for UL CA from RAN2 perspective. Different proposals on how the UE reports supported switching options are raised in [4], [7] and [8], as summarised below.

**Option A:** Try to discuss in RAN2 with assumption that no need to introduce Rel-17 UE capability of UL CA switching option for 2Tx-2Tx switching. The Rel-16 UE capability for 1Tx-2Tx switching applies to 2Tx-2Tx switching as well.

**Option B:** Send LS to RAN1 to ask for clarification on supported switching option for Rel-17 UL Tx switching in UL CA case.

**Option C:** Introduce separate UL Tx Switching Option capabilities for R17 1Tx-2Tx/2Tx-2Tx switching.

**Q8: Which option do companies prefer to handle the capability of supported switching option for Rel-17 UL Tx switching in UL CA case?**

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| --- | --- | --- |
| **Company** | **Option A, B or C** | **Comments** |
| China Telecom | Option A or B | We have no strong view on all the three options.  We slightly prefer to have some discussion from RAN2 perspective, and try to identify the issues that need further RAN1 clarification. |
| Ericsson | Option A | This is also in line with the fallback support (see comments to Q5) and could be the baseline for the signalling. On option B, if the RAN1 discussion is still ongoing, we see no need to rush an LS to RAN1 at this point. On option C, since this is not beneficial in terms of signalling overhead nor confirmed by RAN1, we do not see a need to go for this option either. |
| Qualcomm Incorporated |  | We can simply wait for RAN1 discussion. |
| Nokia, Nokia Shanghai Bell | Option A? | Sending LS doesn't seem necessary unless we have questions to ask. Alternatively, we could also wait for RAN1 as QC proposes. |
| ZTE |  | RAN1 is going to discuss capability after they finish specifying the detailed mechanism of Rel-17 UL Tx switching. So we can simply wait for their input.  If companies think this is urgent, we are also fine to send LS to ask them. |
| MediaTek | Wait for RAN1 |  |
| CATT | Option A or B | Either option A or option B is ok to us, but option C should be avoided. Whether to introduce separate UL Tx Switching Option capabilities for R17 depend on RAN1, RAN2 shall not to introduce such new capabilities without RAN1’s agreement. |
| OPPO | Wait for RAN1 |  |
| Huawei, HiSilicon | Option A | We share the same view as Ericsson.  Option A is align with the RAN4 agreement (supporing 2Tx-2Tx also supports 1Tx-2Tx) in LS. We think it does not make sense if supporting means not in the same option. |
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## RRC configuration

Regarding how to define the RRC configuration for Rel-17 UL Tx switching, different proposals are raised in [4], [7] and [8], as summarised below.

**Option a:** Reuse Rel-16 RRC configuration.

**Option b:** Introduce Rel-17 RRC configuration.

**Option c:** RAN2 to wait for RAN1 further input on RRC configuration for Rel-17 UL Tx switching.

**Q9: Which option do companies prefer to define the RRC configuration for Rel-17 UL Tx switching?**

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| --- | --- | --- |
| **Company** | **Option a, b or c** | **Comments** |
| China Telecom | Option c | No strong view.  And we slightly prefer to have some discussion from RAN2 perspective, and try to identify the issues that need further RAN1 clarification. |
| Ericsson | Option c | We are fine to wait for more RAN1 input. |
| Qualcomm Incorporated | Option C | It is reasonable to wait until the entire feature is clarified. |
| Nokia, Nokia Shanghai Bell | Option C | It's better to wait for RAN1 to avoid having to redo the RAN2 work in case we make wrong assumption. |
| ZTE | Option C | Wait for RAN1. |
| MediaTek | Option C |  |
| CATT | Option c | Better to wait for RAN1’s input before RAN2 take actions. |
| OPPO | Option C |  |
| Huawei, HiSilicon | Option a or Option c |  |
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## Any others issues

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| --- | --- |
| **Company** | **Comments** |
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# Conclusion

# Reference

1. [R2-2106907](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2106907.zip) Reply LS on Rel-17 uplink Tx switching (R1-2104137; contact: China Telecom) RAN1 LS in Rel-17 NR\_RF\_FR1\_enh To:RAN4 Cc:RAN2
2. [R2-2106951](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2106951.zip) LS on Rel-17 Tx switching enhancements (R4-2103234; contact: China Telecom) RAN4 LS in Rel-17 NR\_RF\_FR1\_enh To:RAN1, RAN2
3. [R2-2106953](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2106953.zip) Reply LS on Rel-17 uplink Tx switching (R4-2107847; contact: China Telecom) RAN4 LS in Rel-17 NR\_RF\_FR1\_enh To:RAN1, RAN2
4. [R2-2108274](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2108274.zip) UE capability reporting and RRC configuration for Rel-17 UL Tx switching enhancements China Telecommunication, CATT, Baicells discussion Rel-17 NR\_RF\_FR1\_enh
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6. [R2-2107979](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2107979.zip) UE capabilities for UL Tx switching enhancement Ericsson discussion
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9. [R2-2108159](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2108159.zip) Draft CR to TS38.331 to support Tx switching enhancements Huawei, HiSilicon, China Telecom, Apple, CATT draftCR Rel-17 38.331 16.5.0 NR\_RF\_FR1\_enh
10. [R2-2108160](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2108160.zip) Draft CR to TS38.306 to support Tx switching enhancements Huawei, HiSilicon, China Telecom, Apple, CATT draftCR Rel-17 38.306 16.5.0 NR\_RF\_FR1\_enh
11. [R2-2108672](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2108672.zip) CR to 38.331 on Rel-17 Tx switching enhancements vivo CR Rel-17 38.331 16.5.0 2795 - B NR\_RF\_FR1\_enh
12. [R2-2108673](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2108673.zip) CR to 38.306 on Rel-17 Tx switching enhancements vivo CR Rel-17 38.306 16.5.0 0637 - B NR\_RF\_FR1\_enh